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Manual of Naval Preventive Medicine

Chapter 3

PREVENTION OF HEAT AND COLD STRESS INJURIES (ASHORE, AFLOAT, AND GROUND FORCES)

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Chapter 3
Manual of Naval Preventive Medicine
Heat and Cold Stress Injuries (Ashore, Afloat, and Ground Forces)

12 Feb 2009

To: Holders of the Manual of Naval Preventive Medicine

1. **Purpose.** This revision provides guidance intended to be used in the prevention and treatment of heat and cold stress injuries. The information in this chapter describes the physical and physiological measurements necessary to assess the effects of hot and cold environmental conditions for ashore, afloat, and ground forces.

2. **Background.** The Navy and Marine Corps Public Health Center (NMCPHC) Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, contains more detailed information.

3. **Action.** Replace entire chapter 3 with this version.

A. M. Robinson, Jr.

A. M. ROBINSON, JR.
Chief, Bureau of
Medicine and Surgery

CHAPTER 3
HEAT AND COLD STRESS INJURIES (ASHORE, AFLOAT, AND GROUND FORCES)

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CHAPTER 3
HEAT AND COLD STRESS INJURIES (ASHORE, AFLOAT, AND GROUND FORCES)

Section I. Introduction

3-1. Purpose

a. This chapter provides guidance to be used in the prevention and treatment of heat and cold stress injuries. The information contained in this chapter describes the physical and physiological measurements necessary to assess the effects of hot and cold environmental conditions for ashore, afloat, and ground forces.

b. The Navy and Marine Corps Public Health Center (NMCPHC) Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, contains more detailed information.

3-2. Thermal Stress and Strain

a. Thermal (environmental, physiological, and clothing) stress is the combination of multiple factors working to cause heat gain or loss relative to the body. Figure 3-1 shows how the body gains or loses heat to the environment.

b. Per engineering practices, environmental physiologists employ the term "stress" to designate the force or load acting upon the biological system and the term "strain" to designate the resulting distortion of the biological system. Thermal stress factors include heat, cold, humidity, radiation, air movement, and surface temperatures. Thermal strain manifests itself in specific cardiovascular, thermoregulatory, respiratory, renal, and endocrine responses.

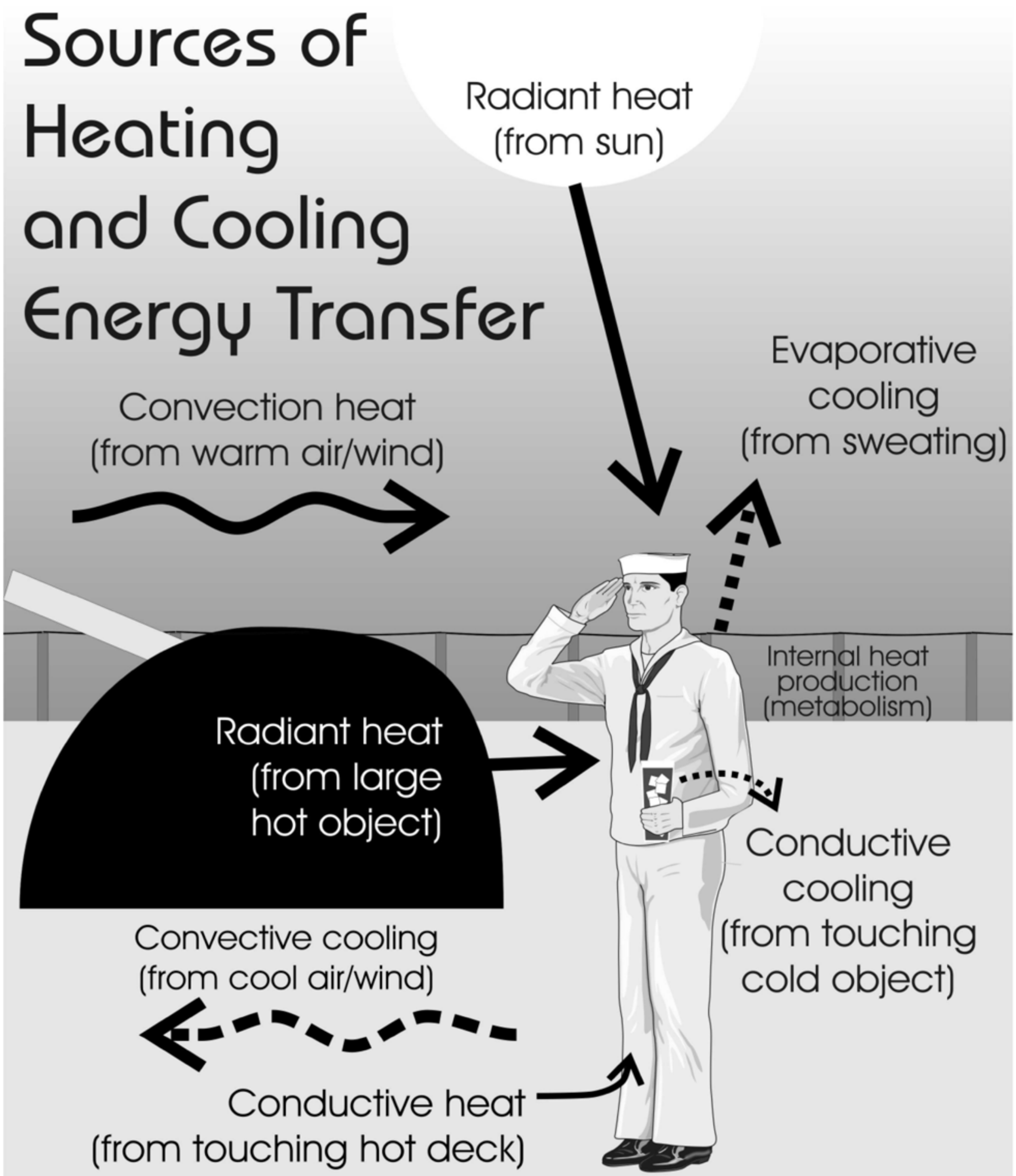

Figure 3-1. How We Gain or Lose Heat to the Environment

CHAPTER 3
HEAT AND COLD STRESS INJURIES (ASHORE, AFLOAT, AND GROUND FORCES)

Section II. Heat Stress

3-3. Heat Stress Effects

a. Heat stress and heat strain have immediate effects, and may have long-term effects on humans. The immediate effects are a significant loss of performance, efficiency, and loss of duty time due to systemic heat injury. Generally, the long-term effects of heat stress and strain are not as apparent as the immediate effects. Prolonged or severe exposure, however, is viewed as contributing to:

- Progressive loss of performance capability.
- Increased susceptibility to other forms of stress.
- Reduced heat tolerance.

b. Each individual should know how to minimize heat stress, recognize symptoms of heat injury, and provide basic first aid (article 3-10). Common heat stress conditions are listed in article 3-4 below.

3-4. Heat Illnesses and Injuries

a. Military populations are prone to heat disorders because battle or training may increase heat stress and limit normal compensatory behavior (such as seeking shade, resting, and drinking water).

b. The spectrum of heat illnesses ranges from mild to severe as body temperature increases:

(1) **Hyperthermia** (i.e., elevated body core temperature) results when the body's cooling system is unable to regulate temperature. This stress to the body can degrade mission performance and morale, increase the risk of accidents, and possibly risk the safety of fellow sailors, mariners, and civilian workers. Sweating is the primary mechanism to cool the body in heat stress conditions. If the signs of heat stress go unrecognized and untreated, serious, even life-threatening health problems can result, such as heat stroke.

(2) **Heat Rash (Miliaria).** Heat rash is a skin irritation caused by heat stress exposure. It usually appears as red bumps on the neck, groin area, or under the arms. Removing the person from heat stress or applying cooling water or non-greasy lotion can help relieve heat rash.

(3) **Heat Syncope.** Heat syncope (fainting) is most likely to occur when unacclimated personnel are first exposed to heat stress. It can usually be avoided by not requiring personnel to stand still in the heat (for example, standing in formation), particularly after exercise.

(4) **Heat Cramps.** Heat cramps are painful cramps, usually affecting the extremities and abdomen. They primarily occur in individuals performing vigorous physical exercise in heat stress conditions. Heat cramps will be lessened upon reducing the intensity of exercise or ceasing physical activity. Electrolyte (salt) replacement can also assist in lessening heat cramps. The use of salt tablets is not recommended. Remove the individual from direct sunlight, remove wet clothing, and have the individual drink small sips of water or sports drink.

(5) **Heat Exhaustion.** Heat exhaustion is a more serious heat injury. Heat exhaustion may be related to either dehydration or salt depletion. Call for medical aid and move the individual to a shaded, ventilated area, and loosen or remove their clothing (unless in a chemical environment). Fan the individual and have them slowly (20 minutes–faster if they are thirsty) drink at least one quart or one full canteen of water. Personnel must obtain medical treatment to ensure they are properly recovering and rehydrating.

(6) **Heat Stroke.** Heat stroke results when the body's ability to maintain core body temperature fails. ***Heat Stroke is a Medical Emergency.*** Rapid cooling of the body and medical attention is vital to survival. The victim must be immediately cooled, as rapidly as possible, and evacuated to a medical treatment facility while cooling measures are continued. Almost any method of cooling (helicopter downdraft, fanning, ice water) may be used.

c. Physical training (PT) and other strenuous physical exercise often cause heat injuries, especially when an individual is:

- Not properly hydrated.
- Not adequately acclimated (acclimatized).
- Exposed to extreme heat, such as direct sunlight, heat producing equipment, or high temperatures.
- Wearing Mission Orientated Protective Posture (MOPP) gear, Firefighting Ensemble (FFE), Radiation Protective Suits, or other Personal Protective Equipment (PPE).
- Inside closed spaces, such as inside an armored vehicle.
- Wearing body armor.

3-5. Training and Reporting

a. Supervisors and those caring for personnel exposed to heat or cold stress shall be familiar with the Navy and Marine Corps Public Health Center (NMCPHC) Technical Manual, NEHC-TM-OEM 6260.6A, Prevention and Treatment of Heat and Cold Stress Injuries, chapters 11 and 12 available at: http://www-nmcphc.med.navy.mil/od/CDRomtoc.htm.

b. Navy educational and training films are available on the effects of heat stress, physical work, water requirements, sodium chloride intake, and predisposing factors for heat disorders. Use of the following films is strongly recommended: "Play It Cool: Heat Stress Prevention Afloat," is an animated all-hands film portraying multiple aspects of heat stress both ashore and afloat. There is also a Navy educational film on "Use and Care of the WBGT Meter" (35335). Those products are available from the Defense Automated Visual Information System/Defense Instructional Technology Information System (DAVIS/DITIS) at http://dodimagery.afis.osd.mil/.

c. All Navy heat stress-related injuries shall be reported through the Naval Disease Reporting System per BUMEDINST 6220.12 series. A simultaneous report to the Naval Safety Center should be made using the Web Enabled Safety System (WESS) per OPNAVINST 5102.1 series.

d. Marine Corps heat injuries shall be reported per MCO P5102.1 series (which prescribes the mandatory use of electronic mishap reporting of all Marine Corps ground mishaps to the Marine Corps database maintained at the Naval Safety Center) and BUMEDINST 6220.12 series (which stipulates Naval Disease Reporting System electronic report, or written, fax, e-mail or telephone report to the cognizant Navy Environmental and Preventive Medicine Unit (NAVENPVNTMEDU)).

3-6. Ship Design Resources. Detailed engineering specifications that relate to heating and cooling design for ships are the responsibility of Naval Sea Systems Command (NAVSEA) and are found in the NAVSEA Technical Manual, Heating, Ventilation, and Air-Conditioning Design Criteria Manual for Surface Ships of the United States Navy, Stock Number 0938-LP-018-0010. Commander, Naval Installations (CNI) has responsibility for shore establishments.

3-7. Environmental Measurements

a. **Dry-Bulb (DB) Temperature.** DB is the prevailing air temperature measured with an ordinary alcohol-in-glass thermometer whose bulb is kept dry and shielded from radiation (radiant heat, such as sunlight). One type of alcohol-in-glass dry-bulb thermometer in the supply system is National Stock Number (NSN) 9G-6685-00-243-9964.

b. **Wet-Bulb (WB) Temperature.** WB is measured with a thermometer, similar to that used for DB temperature, except that a wet wick is fitted closely over the bulb (or sensor). A "natural" WB temperature is obtained with no movement of air over the wick except that which occurs naturally in the environment (unventilated areas will have little air movement, while ventilated or outdoor areas will have more). Although the natural WB temperature depends on the DB temperature and the moisture content of the air, it does not provide a direct indication of the amount of water vapor in the air. The "aspirated" WB temperature is therefore of greater value in planning corrective engineering actions than the "natural" WB temperature, and the term wet-bulb will hereafter refer to that which is aspirated unless otherwise specified. Use of an aspirated or psychometric wet-bulb has been the Navy standard for the past 30 years. When the aspirated WB and DB temperatures are identical the air is said to be "saturated," and the relative humidity is considered to be 100 percent. Any decrease in the moisture content of the air will result in evaporation from the wick of the wet-bulb thermometer, and the thermometer will be cooled to a temperature that reflects the reduced moisture content of the air.

c. **Humidity.** Humidity is an expression of the quantity of water vapor mixed with other atmospheric gases. The absolute humidity (AH) is the mass of water vapor present per unit volume of air (kg/m3); the gas pressure (Torr) exerted by this water vapor is referred to as the vapor pressure (e or VP). The ratio of the actual amount of water in the air (absolute humidity) to the maximum quantity of water that the air can hold at a given temperature is the relative humidity (RH). The temperature at which the AH reaches a maximum and the air becomes saturated with water vapor is called the dew point (Td). VP is a measure of water content in the atmosphere under given conditions.

d. **Psychrometer.** A psychrometer is an instrument for measuring atmospheric humidity utilizing a DB and WB thermometer and whirled manually or by motorized unit to provide the moderate airflow necessary to obtain an aspirated WB temperature reading. The psychrometric chart (Figure 3-2) helps translate this information into RH values and other thermodynamic characteristics of moist air. It is strongly recommended that motorized psychrometers be used for reproducibility of measurements. The NSN for the approved unit is IH-6685-00-935-1389; calibration is not required. Electronic, motorized psychrometers are available to provide direct readout of DB, WB, RH, and Td. Air movement or velocity (V) is usually expressed in feet per minute (fpm) or cubic feet per minute (cfm). Depending upon the velocity of air movement, airflow is measured using different instruments. Low velocities (down to 10 fpm) require a heated Kata thermometer or thermoanemometer ("hot-wire" anemometer or equivalent); high unidirectional air velocities may be measured with a velometer or vane anemometer.

e. **Radiant Heat.** Radiant heat is the transfer of thermal energy by wave motion from one object to another without warming of the intervening space. The wave lengths involved range from the visible portion of the electromagnetic spectrum (0.3-0.7 microns) to the longer radio waves. In industrial situations, any part of the heat radiation spectrum may be present. Natural environments generally include two bands: solar radiation from ultraviolet to near infrared, and heat radiation in the far infrared portion of the spectrum. Both forms of radiation liberate thermal energy when absorbed. Not all of the radiant heat that strikes a surface is absorbed. Any surface that has a high reflectance will minimize absorption of radiant heat; conversely, a surface with low reflectance will increase absorption of radiant heat. The portion that is absorbed is termed "absorptance of the surface" while that which is not absorbed is reflected by the "reflectance of a surface." Humans with dark-pigmented skin and light-colored skin are essentially alike in absorbing the longer wavelength radiant heat (e.g., indoors); however, in the sunlight darker skin has a higher absorptance than lighter skin. The intensity of radiant heat can be measured by use of a radiometer or pyrheliometer, or a globe thermometer (GT).

f. **Globe Thermometer (GT)**

(1) GT is measured using the Vernon GT technique, which consists of a 6-inch hollow copper sphere, with a 0.022 inch thick wall, painted matte (flat) black on the outside, and contains a temperature sensor like that of an unshielded DB thermometer with its bulb, or an equivalent, at the center of the sphere. The black globe temperature typically requires about 20 minutes to reach equilibrium (i.e., to accurately reflect environmental temperature). Smaller globes, from 1.64-2.0 inch outside diameter, have been developed which have shorter equilibrium time.

However, the GT value obtained from the smaller globe should be equated to a GT value from a 6-inch globe using a mathematical algorithm to obtain an accurate Vernon GT measurement. GTs are required in the assessment of thermal stress because they integrate radiant heat exchange and convective heat loss into a single value.

(2) The GT value is neither radiant heat by itself nor what is known as the "mean radiant temperature." The GT value is a composite of radiant and convective heat transfers.

(3) While there are several heat stress equations or indexes that provide heat exposure, the only index authorized by the Bureau of Medicine and Surgery (BUMED) is the WBGT index.

g. **Heat Stress Index (HSI).** The HSI provides heat exposure guidance only using DB and RH values and does not incorporate GT. BUMED does not approve the use of HSI to provide heat exposure guidance to Navy and Marine Corps personnel. Wet-Bulb Globe Temperature (WBGT) is the only BUMED-approved heat stress index.

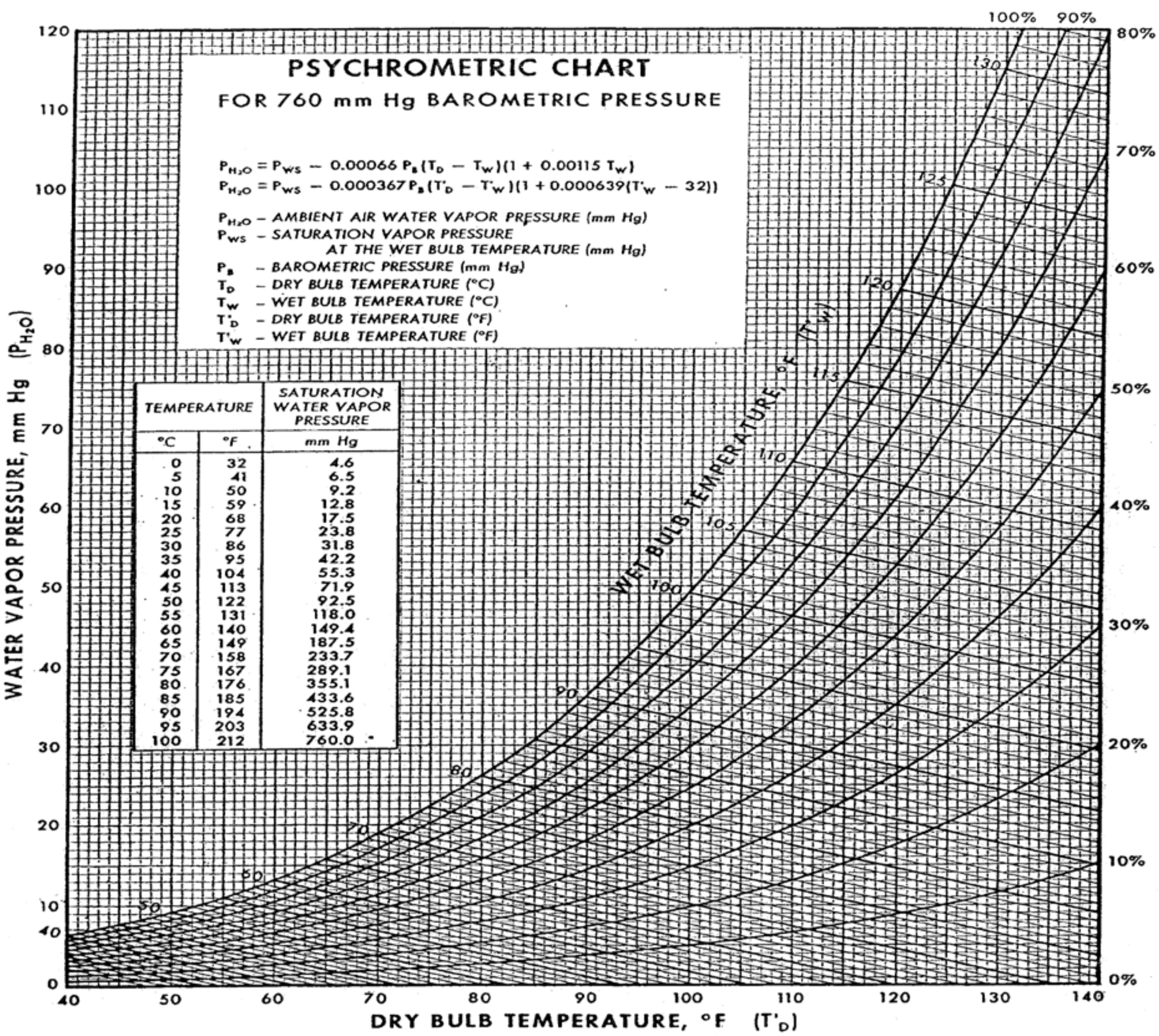

Figure 3-2. Psychrometric Chart

h. **Wet Globe Temperature (WGT) Index.** The WGT or "Botsball" has been used in the distant past to obtain heat stress measurements. However, BUMED does not endorse use of the WGT Botsball to determine heat stress guidance for Navy and Marine Corps personnel.

i. **Wet-Bulb Globe Temperature (WBGT) Index**

(1) WBGT is unique in that it takes into account the four physical variables of the thermal environment (air temperature, DB; humidity or how moist the air is, RH or WB; radiant heat, GT; and air movement). WBGT is obtained from the measurement of DB, GT, and WB (measured directly or derived from RH) and is calculated as (DB x 0.1) + (GT x 0.2) + (WB x 0.7). While there are numerous WBGT equations, the above equation is the standard for all Navy and Marine Corps environments (indoor and outdoor). Direct measurement of air velocity is not necessary and the GT integrates radiant heat and convective heating and cooling into one value.

(2) Other indices of heat stress and strain are of limited use.

j. **Equipment**

(1) WBGT Meter, also known as a Heat Stress Meter, is the approved BUMED environmental measurement device. The heat stress meter is a compact instrument that independently measures the DB temperature, WB temperature or relative humidity, and globe temperature. The instrument displays each of these values as well as computes and displays the WBGT Index value. Currently, the approved heat stress meters (specified in OPNAVINST 5100.19 series) are identified below:

- The RSS-220 Heat Stress Meter (Figure 3-3) is described and portrayed in the Navy educational film "Care and Use of the Heat Stress Meter" (35335-DN).

- The Vista 960 is also an approved meter but is no longer in production. This meter may be used until it is no longer repairable.

- The Automated Heat Stress System (AHSS) (Figure 3-4), is described in article 3-7(j)(2).

- The Stortz WBGT Kit; is primarily used by Marine Corps personnel in the field.

(2) The AHSS provides a measurement of WBGT through the use of a DB, GT, and RH sensor. This computerized system automatically measures the WBGT environment and calculates the appropriate heat exposure guidance for both afloat and ashore personnel. The AHSS displays the data every minute, stores the data in a file on the computer hourly, and can print out a heat stress survey on demand. A WB value (psychometric/aspirated WB value) is derived from the measured DB and RH values. The advantage of using an RH sensor is that the RH value can provide information on the potential for evaporation of sweat to cool the body (i.e., 15 percent RH is a dry environment while 75 percent RH is a humid/wet environment). In

contrast a WB value is of little use without knowing the DB value. Additionally, the RH sensor does not require constant maintenance to keep the wick clean and properly wetted. Use of the AHSS has been implemented afloat to provide PHELs stay time guidance and ashore to provide flag condition guidance. AHSS units do not need calibration stickers.

(3) Commands may use commercial off-the-shelf (COTS) portable direct reading heat stress monitors for shore establishment measurements. Ensure GT is Vernon 6-inch equivalent and the overall measurement accuracy is within 1°F or 0.5°C. With any heat stress meter, careful monitoring and adherence of procedures and equipment maintenance is necessary to ensure valid assessment of WBGT conditions. For all measurements, ensure that:

- Outside readings are measured in an area that is not shaded and is likely to reflect conditions experienced by troops.
- Heat Stress Meters are kept clean, calibrated, and operational.
- WB measurements are taken using a clean 100 percent cotton wick which extends into clean, non-mineralized water, and above the thermometer reservoir; or WB measurements are derived from DB and RH values.
- Heat stress data is consistently recorded in a heat stress log.

(4) Stock numbers for the Navy and Marine Corps approved WBGT Meters are as follows:

- RSS-220 WBGT Meter, NSN 7G-6685-01-055-5298 (Shipboard AEL 2-870003051).
- Accessories (spare sensor/wind tunnel assembly, globe, wicks, etc.)
  NSN 90-6685-01-055-5299 (Shipboard APL 100l10001).
- Globe Assemblies NSN 90-6665-01-149-8635.
- Standard Nickel-Cadmium Rechargeable AA Batteries, NSN 90-6140-00-449-6001.
- The Stortz WBGT Kit, NSN 6665-00-159-2218.
- AHSS Unit, NSN 7H H 6685-LL-H54-6414.

Figure 3-3. RSS-220

Figure 3-4. **Automated Heat Stress System (AHSS)** Unit

k. **Flag Condition**

(1) Flag condition refers to a series of outdoor WBGT environments that provide ashore heat exposure or physical activity guidance to Navy and Marine Corps personnel.

(2) Flag condition guidance, contained in Table 3-1, is not a substitute for the PHEL curves nor is it possible to comply with this guidance in combat situations. When the WBGT Index reach specific temperatures, color-coded flags are flown in strategic locations so all personnel will be aware of the current heat stress index and make appropriate work schedule adjustments. Since shore facilities vary in size geographically, the flag, which is closest to the specific site during hot weather operations, should be used to determine level of the specific operation.

- **Green Flag** (WBGT Index of 80°F to 84.9°F). Heavy exercises for unacclimated personnel shall be conducted with caution and under constant supervision. Organized PT evolutions in boots and utilities are allowed for all personnel.
- **Yellow Flag** (WBGT Index of 85°F to 87.9°F). Strenuous exercises, such as marching at standard cadence, shall be suspended for unacclimated troops in their first 2 or 3 weeks. Avoid outdoor classes in the sun.
- **Red Flag** (WBGT Index of 88°F to 89.9°F). All physical training shall be halted for those troops who have not become thoroughly acclimated by at least 12 weeks of living and working in the area. Those troops who are thoroughly acclimated may carry on limited activity not to exceed 6 hours per day.
- **Black Flag** (WBGT Index of 90°F and above). All strenuous outdoor physical activity that is not essential (***including organized or unorganized PT***) mission accomplishment shall be halted for all units.

(3) Wearing body armor or nuclear, biological, or chemical (NBC) protective uniforms adds approximately 10 points to the measured WBGT. Limits of exposure should be adjusted accordingly.

(4) PHEL curve and Flag condition heat exposure guidance are based solely on WBGT index. Use of the Heat Stress Index to provide PHEL or Flag guidance is not authorized.

Table 3-1. Regulating Physical Exertion in Hot Weather by Wet-Bulb Globe Temperature (WBGT) Index

Flag Color	WGBT Index (F)	Intensity of Physical Exercise
Green 	**80 – 84.9**	Discretion required in planning heavy exercise for unseasoned personnel.
Yellow 	**85 – 87.9**	Strenuous exercise and activity (e.g., close order drill) should be curtailed for new and unacclimated personnel during the first 3 weeks of heat exposure.
Red 	**88 – 89.9**	Strenuous exercise curtailed for all personnel with less then 12 weeks training in hot weather.
Black 	**90 and Above**	Physical training and strenuous exercise suspended for *all personnel* (excludes operational commitment not for training purposes).

Note: This table may not be used in lieu of the PHELs for afloat commands.

l. **Activity Level.** Essential outdoor physical activity will be conducted at a level appropriate for the degree of personnel heat acclimatization as determined by the unit's commanding officer in coordination with the unit's medical officer or medical personnel. All efforts should be made to reschedule major hot weather training activities to occur during cooler periods of the day, such as early morning or late evening.

3-8. Afloat

a. PHEL Curves

(1) In 1973 the Navy developed a series of six PHEL curves based on a sequence of laboratory and shipboard studies. These curves determine maximum exposure limits or stay times for various environmental conditions and individual work rates. The Navy's PHEL limits, which allow core temperature rise to 102.2°F (39°C), recognize that under conditions of maximum work and heat stress the heat strain will be readily apparent, but it will be reversible. In contrast, National Institute for Occupational Safety and Health (NIOSH) Permissible Exposure Limits (PELs) were designed to restrict core temperature rises to a maximum of 100.4° F (38°C). The Navy's PHEL curves assume personnel are healthy and acclimatized. Since the PHEL curves apply to greater than 95 percent of the naval population, there may be

individuals who occasionally exceed the stay times without incurring a heat injury, and conversely, there may be individuals who incur a heat injury without exceeding the stay times. However, non-compliance with the PHEL stay times will increase the potential for serious heat injuries.

(2) To obtain accurate and reliable data on heat-stress conditions, ships must conduct heat-stress surveys to record DB, WB or RH, and GT readings to calculate the WBGT index. The Navy uses either a WBGT or HSM meter or an AHSS unit to obtain this environmental information. The WBGT index and the individual's physical exertion level (PHEL curve rating) are used to calculate an individual's allowable stay time.

(3) To accurately determine dry-bulb readings, a DB thermometer (alcohol-in-glass, NSN 9G-6685-00-243-9964) shall be used. It is important that DB thermometers not be installed within 2 feet of any supply ventilation terminal/opening and that non-conductive material is used to hang the DB thermometer. Thermometers containing mercury shall not be used.

(4) The AHSS unit uses an RH sensor which provides a WB reading for use in the WBGT calculation; it does not use a wick that personnel must keep clean and wet. The AHSS constantly monitors the environment producing real time WBGT and PHEL stay time values that are sent to a computer for displaying the heat stress data. Shipboard locations that have ventilation air flow directed at an AHSS unit must be adjusted such that the airflow across the sensor does not exceed 600 fpm.

b. **Determining Stay Time Using PHEL Curves**

(1) To determine the correct PHEL curve stay time, both the WBGT index and the degree of effort entailed by the particular job are required. The more strenuous the job the shorter the allowable exposure limit. Each of the six PHEL curves pertains to a different work rate, ranging from light work (PHEL Curve I) to heavy work (PHEL Curve VI). Figure 3-5 provides the relationships of various metabolic rates, heat stress, and maximum safe exposure times. Examples of light work include sweeping/mopping, painting, adjusting automatic combustion controls, changing and cleaning lube oil strainers, and bleeding hydraulic oil. Examples of heavy work include manually chipping and wire brushing in preparation for painting, handling cargo and supplies, replacing large valves, cleaning lube oil sumps, and disassembly or reassembly of large or heavy equipment. The PHEL curves apply to normal, healthy personnel who have had adequate rest (6 hours continuous sleep in the last 24 hours), adequate water intake, and adequate recovery time from previous heat-stress exposure (2 hours recovery for every 1 hour exposure or 4 hours maximum). Personnel are assumed to be wearing clothing consisting of at least 35 percent cotton fiber, not containing starch, and readily permeable to water.

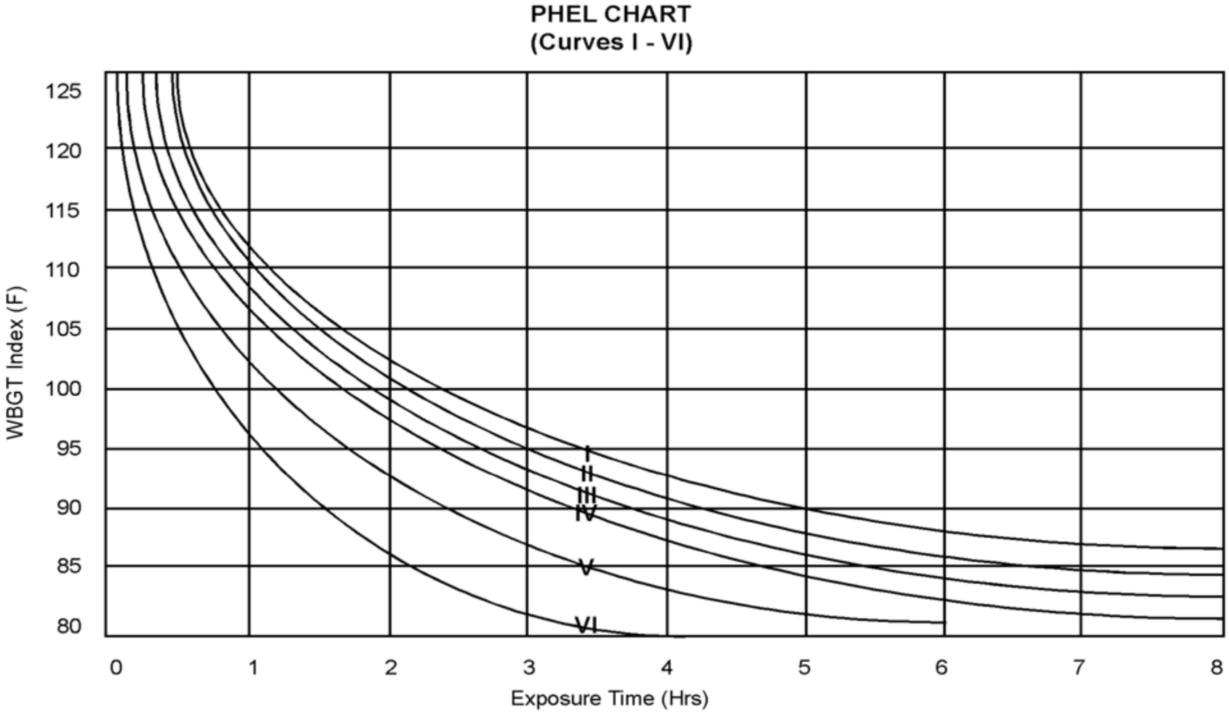

Figure 3-5. PHEL Chart

(2) It must be emphasized that the PHELs are maximum allowable standards and they should be applied only in cases of short-term work exposures of up to 8 hours duration. The limits presume that no prior heat injury or predisposing condition is present and that no cumulative heat fatigue exists prior to re-exposure. Also, full acclimation to the present heat stress environment is assumed.

(3) The PHEL curves do not provide heat exposure guidance for personnel wearing layered or impermeable clothing such as chemical/biological warfare clothing, firefighting protective clothing or ensemble, or chemical protective clothing (worn for use during clean-up of hazardous material spills) or any type of body cooling garment or device.

(4) PHEL curves for routine watches and casualty control exercises are given in Table 3-2, Table 3-3, and Figure 3-5. PHEL curves in Table 3-4 apply where there is the apparent presence of fuel combustion gases (or “stack gas”) and/or fuel vapors. Time Weighted Mean (TWM) metabolic rates, activity (including movements about the spaces) and lengths of time of the activity have been taken into account. For Remaining Safe Stay Time situations where different heat stress conditions, actual exposure times and/or recovery times apply, see article 3-8h.

c. **Watch Duration.** Under normal operations, routine watches in engineering spaces are expected to be 4 hours at a PHEL III or lower. PHEL IV through VI apply to above average work rates. Heat stress surveys shall be conducted for PHEL I through III at a DB temperature of 100°F when the Watch/Work length is 4 hours or less. If the Watch/Work length is greater than 4 hours, then the Heat stress survey shall be conducted when the DB is 90°F or greater. For PHEL IV through VI, a DB temperature of 85°F indicates a heat stress survey should be taken.

d. **Rounding the WBGT to a Whole Number.** To use the PHEL table, the recorded WBGT index is rounded to the next higher whole number value. For example: 85.1°F would be rounded to 86°F and 89.9°F would be rounded to 90°F; but 92.0°F would remain 92°F. Using the whole number value of the WBGT index, the heat-stress surveyor would obtain the permissible stay time in hours and minutes under the column for the PHEL curve determined using Table 3-3. Hence, for a recorded WBGT index of 85.1º F or 85.8ºF (both rounded to 86°F), the stay time for PHEL Curve III is 5 hours, 55 minutes.

e. **Fuel Combustion Gas Impact**

(1) Fuel Combustion Gases (Stack Gas) and fuel vapors can have severe physiological impact on personnel and a reduction in PHEL stay times. The effects of these environmental factors are intensified by heat stress. Prolonged exposure to relatively low concentrations can impact the ability of personnel to work safely. If someone entering a workspace or area for the first time in approximately 4 hours or more can smell the odor of stack gas and/or fuel vapors, then a harmful concentration may be present. Personnel should be checked for the following symptoms:

- Eyes watering and/or burning, sore throat, i.e., irritation of mucous membranes.
- Difficulty in breathing normally.
- Tingling or numbness of the tip of the tongue, tip of the nose, finger tips and/or toes.
- Impaired senses or judgment.

(2) If two or more of the above symptoms are exhibited, then exposure limits must be reduced as follows:

- Prompt removal of affected personnel to fresh air is essential.
- Using the latest WBGT index values, determine the PHEL stay time by using Table 3-4.
- Calculate the PHEL stay time for existing heat-stress conditions, and divide that stay time by three to obtain the new stay time. For example, if the exposure limit due to heat stress is 4 hours, then the exposure limit with stack gas and or fuel vapors present would be reduced to 1 hour, 20 minutes.

f. **Curve Selection**

(1) Applicable PHEL curves should be determined by selecting the appropriate curve listed in Table 3-2.

(2) Non-routine operations, such as performing operations in out-of-normal plant configurations, increases in normal watchstander work rate, and minor equipment casualties require the use of the next higher number curve above that specified in Table 3-2 for routine operations. For example, if the stay time for a particular watchstander is determined to be PHEL Curve I during normal operations, then the exposure limit for the watchstander should be determined using PHEL Curve II during difficult or more active than normal watches.

(3) Engineering Casualty Control Exercises watchstanders shall have their stay times determined by selecting the appropriate curve listed in Table 3-2.

(4) Personnel conducting heavy repairs or other strenuous work shall have their stay time determined by using PHEL Curve VI.

(5) As indicated, the PHEL curves and the assignment in Table 3-2 are based on normal, healthy personnel who have adequate rest and recovery from previous heat-stress exposures. Personnel having repetitive exposures to heat stress without sufficient recovery time may experience cumulative fatigue. Additionally, personnel with a cold and/or respiratory infection, lacking sufficient sleep (less than 6 hours in the past 24 hours), experiencing dehydration, having clinically confirmed hypertension or taking medication which adversely effects body temperature are much more prone to systemic heat injuries. Maximum exposure limits for these personnel cannot be reliably predicted using the PHEL Chart. The senior medical department representative on a case-by-case basis shall determine appropriate exposure limits for these personnel.

(6) If, after determining personnel stay times a heat injury occurs, then the stay times for all other personnel in the space shall immediately be reduced by recalculating stay times using the next numerically higher PHEL curve than specified by Table 3-3. The work and health status of the individual suffering the injury shall be promptly reviewed. When the cause of the injury has been determined, the stay times for personnel in the space shall be determined using the latest WBGT index and the normally appropriate curves as indicated in Table 3-3.

Table 3-2. Physiological Heat Exposure Limits (PHEL) Curve General Applicability Aboard Ships

PERSONNEL	PHEL CURVE	
	Routine Watch	Casualty Control Drills
Steam Propelled Ships		
Propulsion Spaces		
1. BTOW	II	III
2. Console Operator	I	I
3. Upper Levelman (checkman)	II	III
4. Lower Levelman	II	III
5. MFP Watch	II	III
6. Burnerman	II	III
7. EOOW	I	I
8. MMOW	II	III
9. Throttleman	I	I
10. EMOW	I	I
11. Upper Levelman (SSTG)	II	III
12. Lower Levelman (Lube Oil/Condensate)	II	III
13. Evaporator Watch	I	II
14. Messenger (see note below)	III	IV *
Auxiliary Spaces		
All Watches	II	II
Diesel Propelled Ships		
1. EOOW	I	I
2. POOW	II	III
3. EMOW	I	I
4. Throttleman	I	I
5. Repair Electrician	I	I
6. SSDG Watch	I	I
7. Boiler Watch	I	I
8. Evaporator Watch	II	II
9. Oiler/Messenger	III	IV
Gas Turbine Propelled Ships		
FFG-7 and CG-47 Class Ships		
All Engineering Watch Personnel	I	II
DDG-51 Class Ships		
1. ERO	II	II
2. PSM/ERM	II	III
3. ASM	II	III
4. AS/VCDO	II	III
5. Sounding and Security Watch	III	III
6. OD Box Watch (see note below)	NA	II **
AOE Class Ships		
1. PSM	II	II
2. ASM	II	III
3. Auxiliary Rover	III	III
Aircraft Carriers (CV/CVNs)		
Steam Catapult Spaces (including water break rooms)		
All Watches	II	II
All Other Surface Ship Spaces		
1. ECC Monitors/Inspectors	I	II
2. Laundry Personnel	III	NA
3. Scullery Personnel	V	NA
4. Food Service Personnel	II	NA
5. Elevator Machinery Rooms	II	II
Submarines		
Engine Room		
1. EOOW	I	I
2. EWS	II	III
3. Throttleman	I	I
4. Reactor Operator	I	I
5. Electrical Operator	I	I
6. Upper Level	II	III
7. Lower Level	II	III
8. Evaporator Watch	I	II
9. Engineering Drill Monitors	NA	II
Auxiliary Spaces		
All Watches	II	II
Other Spaces		
Food Service Personnel	II	NA

* Messenger stay times should be determined by taking the average of all WBGT Index values for the space not including the console booth. In most cases this will give a longer stay time than using PHEL Curve values listed for the messenger above.

** Includes restricted maneuvering and casualty control drills.

g. **Time Weighted Mean (TWM) WBGT**

(1) The TWM WBGT value is intended for use in especially hot environments where reduced stay times have been imposed on personnel. The TWM WBGT is an optional provision, for use if an air-conditioned booth or cooler workspace is available to afford some relief from the heat. When the TWM is used it changes the WBGT value for that individual and increases the length of time spent at the watch station or work location. Proper calculation of the TWM WBGT is as follows:

Time (Cooler space) =	$\frac{\text{[WBGT (work location) – WBGT (desired)] x 60}}{\text{WBGT (work location) – WBGT (cooler space)}}$

Example: Engineering spaces on a steam-powered ship in the Indian Ocean are manning a 4-hour watch rotation. The temperature on a hanging DB thermometer in a main space measured 101°F during the latest heat-stress survey:

Burnerman	WBGT = 92	PHEL = II	Stay Time = 4:10
Lower Levelman	WBGT = 92	PHEL = III	Stay Time = 3:30
Console Booth	WBGT = 80	PHEL = I	Stay Time = 8:00

The Lower Levelman has a stay time less than 4 hours while other watchstations have stay times that are equal to or greater than 4 hours. The engineer officer decides to incorporate a TWM WBGT for the Lower Levelman to maintain a 4-hour watch for all watchspace personnel. He/she looks up the WBGT value (in Table 3-3) to achieve a 4-hour stay time (90 WBGT = stay time of 4 hours) and does the calculation. The time that the Lower Levelman must spend in the cool booth each hour to achieve a 4-hour watch would be calculated as follows:

For the Lower Levelman:

Time (booth) =	$\frac{\text{(WBGT (watch station) – WBGT (desired)) x 60}}{\text{WBGT (watch station) – WBGT (booth)}}$

The 90 WBGT value is from the PHEL Table

Time (booth) =	$\frac{92-90 \times 60}{92-80}$	= 10 minutes

Thus, if the Lower Levelman can spend 10 minutes each hour in the cool booth, he may work a 4-hour watch.

**Table 3-3. PHEL Time Limits for PHEL Curves I-VI
Without the Presence of Fuel Combustion Gases/Fuel Vapors**

WBGT Index (F)	Total Exposure Time in Hours:Minutes					
	I	II	III	IV	V	VI
80.0	>8:00	>8:00	>8:00	8:00	6:35	4:30
81.0	>8:00	>8:00	>8:00	7:45	6:00	4:05
82.0	>8:00	>8:00	8:00	7:05	5:25	3:40
83.0	>8:00	8:00	7:45	6:25	4:55	3:20
84.0	>8:00	8:00	7:05	5:55	4:30	3:05
85.0	8:00	7:45	6:30	5:20	4:05	2:50
86.0	8:00	7:05	5:55	4:55	3:45	2:35
87.0	7:25	6:30	5:25	4:30	3:25	2:20
88.0	6:45	5:55	4:55	4:05	3:10	2:10
89.0	6:10	5:25	4:30	3:45	2:50	2:00
90.0	5:40	5:00	4:10	3:25	2:40	1:50
91.0	5:15	4:35	3:50	3:10	2:25	1:40
92.0	4:50	4:10	3:30	2:55	2:15	1:30
93.0	4:25	3:50	3:15	2:40	2:00	1:25
94.0	4:05	3:35	3:00	2:25	1:50	1:15
95.0	3:45	3:15	2:45	2:15	1:45	1:10
96.0	3:25	3:00	2:30	2:05	1:35	1:05
97.0	3:10	2:45	2:20	1:55	1:25	1:00
98.0	2:55	2:35	2:10	1:45	1:20	0:55
99.0	2:40	2:20	2:00	1:40	1:15	0:50
100.0	2:30	2:10	1:50	1:30	1:10	0:45
101.0	2:20	2:00	1:40	1:25	1:05	0:45
102.0	2:10	1:50	1:35	1:15	1:00	0:40
103.0	2:00	1:45	1:25	1:10	0:55	0:35
104.0	1:50	1:35	1:20	1:05	0:50	0:35
105.0	1:40	1:30	1:15	1:00	0:45	0:30
106.0	1:35	1:25	1:10	0:55	0:45	0:30
107.0	1:30	1:15	1:05	0:50	0:40	0:25
108.0	1:20	1:10	1:00	0:50	0:35	0:25
109.0	1:15	1:05	0:55	0:45	0:35	0:25
110.0	1:10	1:00	0:50	0:40	0:30	0:20
111.0	1:05	1:00	0:50	0:40	0:30	0:20
112.0	1:00	0:55	0:45	0:35	0:25	0:20
113.0	0:55	0:50	0:40	0:35	0:25	0:15
114.0	0:55	0:45	0:40	0:30	0:25	0:15
115.0	0:50	0:45	0:35	0:30	0:20	0:15
116.0	0:45	0:40	0:35	0:25	0:20	0:15
117.0	0:45	0:40	0:30	0:25	0:20	0:10
118.0	0:40	0:35	0:30	0:25	0:15	0:10
119.0	0:35	0:35	0:25	0:20	0:15	0:10
120.0	0:35	0:30	0:25	0:20	0:15	0:10
121.0	0:35	0:30	0:25	0:20	0:15	0:10
122.0	0:30	0:25	0:20	0:15	0:15	0:10
123.0	0:30	0:25	0:20	0:15	0:10	0:10
124.0	0:25	0:25	0:20	0:15	0:10	0:05
125.0	0.25	0.20	0.20	0.15	0.10	0.05

Table 3-4. PHEL Time Limits for PHEL Curves I-VI With the Presence of Fuel Combustion Gases/Fuel Vapors

WBGT Index (F)	Total Exposure Time in Hours:Minutes					
	I	II	III	IV	V	VI
80.0	4:50	4:15	3:30	2:55	2:15	1:30
81.0	4:25	3:50	3:10	2:40	2:00	1:20
82.0	4:00	3:30	2:55	2:25	1:50	1:15
83.0	3:40	3:10	2:40	2:10	1:40	1:10
84.0	3:20	2:55	2:25	2:00	1:30	1:00
85.0	3:00	2:40	2:10	1:50	1:25	0:55
86.0	2:45	2:25	2:00	1:40	1:15	0:50
87.0	2:30	2:10	1:50	1:30	1:10	0:45
88.0	2:20	2:00	1:40	1:25	1:05	0:40
89.0	2:05	1:50	1:30	1:15	1:00	0:40
90.0	1:55	1:40	1:25	1:10	0:55	0:35
91.0	1:45	1:30	1:15	1:05	0:50	0:30
92.0	1:35	1:25	1:10	1:00	0:45	0:30
93.0	1:30	1:20	1:05	0:55	0:40	0:25
94.0	1:20	1:10	1:00	0:50	0:35	0:25
95.0	1:15	1:05	0:55	0:45	0:35	0:20
96.0	1:10	1:00	0:50	0:40	0:30	0:20
97.0	1:10	0:55	0:45	0:40	0:30	0:20
98.0	1:05	0:50	0:40	0:35	0:25	0:15
99.0	0:55	0:45	0:40	0:30	0:25	0:15
100.0	0:50	0:45	0:35	0:30	0:20	0:15
101.0	0:45	0:40	0:35	0:25	0:20	0:15
102.0	0:40	0:35	0:30	0:25	0:20	0:10
103.0	0:40	0:35	0:30	0:25	0:15	0:10
104.0	0:35	0:30	0:25	0:20	0:15	0:10
105.0	0:35	0:30	0:25	0:20	0:15	0:10
106.0	0:30	0:25	0:20	0:20	0:15	0:10
107.0	0:30	0:25	0:20	0:15	0:10	0:10
108.0	0:25	0:25	0:20	0:15	0:10	0:05
109.0	0:25	0:20	0:15	0:15	0:10	0:05
110.0	0:25	0:20	0:15	0:15	0:10	0:05
111.0	0:20	0:20	0:15	0:10	0:10	0:05
112.0	0:20	0:15	0:15	0:10	0:10	0:05
113.0	0:20	0:15	0:15	0:10	0:05	0:05
114.0	0:15	0:15	0:10	0:10	0:05	0:05
115.0	0:15	0:15	0:10	0:10	0:05	0:05
116.0	0:15	0:10	0:10	0:10	0:05	0:05
117.0	0:15	0:10	0:10	0:05	0:05	0:05

h. **Remaining Safe Stay Time**

(1) **Impact of Personal Status Change on Exposure Limits.** If a person's status changes during the period of a watch, e.g., the person assumes a watch in a different location or works at a different exertion level, stay times shall be computed using the procedures for remaining safe stay times.

(2) There are a number of situations where it is necessary to estimate the remaining safe stay times relative to various heat stress conditions, different work levels and/or to account for recovery periods. A simplified approach to estimating the remaining safe stay times is given in the below equation:

Table 3-5. Remaining Safe Stay Time Equation

RSSt = [1 -({Et -R/2} / At1)] x [At2]
Where: RSSt = remaining safe stay time (in minutes) Et = elapsed time on station (in minutes) R = recovery time in a cool environment (in minutes) At1 = allowed PHEL time in first environment (in minutes) At2 = allowed PHEL time in second environment (in minutes)

Note: Application of the Remaining Safe Stay Time Equation assumes some cumulative fatigue will take place.

(3) Four examples will help illustrate calculating Remaining Safe Stay Times:

(a) The level of physical work was changed from heavy to light work and the heat stress is higher in the light work phase, the elapsed time of the first exposure is known, and no recovery is permitted between the two levels of physical work.

- Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).
- The first heat stress condition had a WBGT of 83.0°F and work was consistent with PHEL Curve VI. [PHEL VI at 83.0°F permits a maximum of 3 hours, 20 minutes (200 minutes)].
- There was no recovery in a cool environment between the first environment and the second (WBGT 94.3°F (which is rounded to 95°F) with work equal to PHEL Curve I). [PHEL I at 95°F permits a maximum of 4 hours (240 minutes).]
- Therefore, RSSt#l = [1 -({180 -(0/2)} / 200)] * [240] = 24 minutes. The second exposure situation should not exceed 24 minutes.

(b) The level of physical work was unchanged at the same heat stress level but the two exposures were separated by a 40-minute recovery period in a cool environment; the elapsed time was known for the first exposure.

- Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).
- Both heat stress conditions had WBGT values of 91.3°F (which is rounded to 92°F) and the level of work was consistent to PHEL Curve I in both cases. [PHEL I at 92°F permits a maximum of 5 hours, 8 minutes (308 minutes) each].
- Recovery, between the two exposures, was permitted for 40 minutes.
- Therefore, RSSt#2 = [1 -({180 -(40/2)} / 308)] x [308] = 148 minutes or 2 hours, 28 minutes. The second exposure situation should not exceed 2 hours, 28 minutes.

(c) The level of physical work was the same in two different heat stress environments, the exposure time in the first condition was known, and the two exposures were separated by a 40-minute recovery in a cool environment.

- Elapsed exposure time in the first heat stress condition was 3 hours (180 minutes).
- The first heat stress condition had a WBGT of 91.3°F (which is rounded to 92°F) and work equaled that for PHEL Curve I. [PHEL I at 92°F permits a maximum of 5 hours, 8 minutes (308 minutes)].
- There was 40 minutes recovery in a cool environment between the first environmental exposure, and the second exposure at a WBGT of 94.3°F (which is rounded to 95°F) with work equivalent to PHEL Curve I. [PHEL Curve I at WBGT of 95°F permits 4 hours (240 minutes) stay time].
- Therefore, RSSt#3 = [1 -({180 -(40/2)} / 308)] x [240] = 115 minutes or 1 hour, 55 minutes. The second exposure situation should net exceed 1 hour, 55 minutes.

(d) The level of physical work changed from an intermediate level to lighter level and the heat stress was considerably higher during the second exposure. Both the elapsed time for the first exposure and the recovery time between exposures were known.

- Elapsed exposure time in the first heat stress condition was 3 hours, 15 minutes (195 minutes).
- The first heat stress condition had a WBGT of 87.7°F (which is rounded to 88°F) and work was consistent with PHEL Curve IV. [PHEL IV at 88°F permits a maximum of 4 hours, 15 minutes (255 minutes)].
- There was 50 minutes recovery in a cool environment between the first exposure and the second; the work during the second exposure was equivalent to PHEL Curve II, but the WBGT value was 100.9°F (which is rounded to 101°F) for the second exposure. [PHEL II at 101°F allows a maximum of 2 hours, 5 minutes (125 minutes)].
- Therefore, RSSt#4 = [1 -({195 -(50/2)} / 255)] x [125] = 42 minutes. The second exposure situation should not exceed 42 minutes.

i. **Alternative Measures**. It is sometimes impossible to control environmental heat within the specified limits in the face of increased operational demands. Alternative measures may therefore be useful in limiting heat stress and reducing the incidence of heat casualties. Several options are possible; see Table 3-6:

Table 3-6. Measures to Limit Heat Stress and Reduce Incidence of Heat Casualties

1. Insulate the source of heat.
2. Ventilation with cool air.
3. Reduce humidity (partial water vapor content) by stopping steam leaks and venting steam to the outside.
4. Provide clothing that will maximize evaporative cooling.
5. Cool garments or systems.
6. Limit exposure time (refer to PHEL Chart).
7. Avoid cumulative fatigue; maintain overall physical health.
8. Spray with water mist.
9. Eliminate the presence of fuel combustion gases and fuel vapors.
10. Modify work rest cycles.
11. Automate and isolate operations that generate excessive heat when feasible.

j. WBGT Estimation

(1) Emergency estimation of WBGT may be performed if no working WBGT equipment is available.

(2) The emergency environmental monitoring equipment method discussed here will almost always significantly underestimate the level of heat stress; this shortfall will result in an increased risk of personnel suffering heat injury. When there are no operable WBGT meters aboard ship, there are two alternative monitoring methods that may be used while the ship is underway. Motorized psychrometers (NSN 1H-6685-00-936-1389), carried aboard ships for meteorological purposes, or commercially available hygrometers. These psychrometers only measure DB and WB temperatures. They do not have a globe thermometer and therefore cannot account for radiant and convective heating or cooling. Hence all of the components in the WBGT Index equation are not available to calculate the WBGT Index. If using the motorized psychrometers DB and WB temperatures must be measured with the psychrometer shield in its proper position (the flared-open end of the shield must be facing away from the psychrometer). GT can be approximated by taking the difference (ΔT) between the DB temperature and the GT from previous heat stress surveys conducted under similar plant operating conditions (power level, number of operating boilers, and approximately the same load on the propulsion plant). This difference (ΔT) should be added to the DB temperature measured with the psychrometer. For example:

Table 3-7. Sample Calculation of Estimated WBGT

Psychrometer WB	83.6	Previous GT	110.4
Psychrometer DB	99.1	Previous DB	98.3
		ΔT =	12.1
Estimated GT(DB+ ΔT) = 99.1 + 12.1 = 111.2			
WBGT = (0.1 x DB) + (0.7 x WB) + (0.2 x GT)			
WBGT = (0.1 x 99.1) + (0.7 x 83.6) + (0.2 x 111.2)			
WBGT = 90.7			

(3) The WBGT Index values obtained by this strictly emergency monitoring method should be used with the PHEL Chart (Figure 3-5) or Tables (Tables 3-3 and 3-4). The resultant exposure limits will be approximations only.

3-9. Shore and Ground Forces

a. Shore Commands Guidance

(1) For shore commands the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV)® for Chemical Substances and Physical Agents and Biological Exposure Indices (BEI)® (most current edition) the information in Table 3-8 should be used as guidance to determine work/rest criteria for work situations in a heat stress environment. Examples of typical work levels for Navy/Marine Corps shore settings are found in Table 3-9. Work/rest criteria do not apply for physical fitness or physical training activities where the heat stress flag conditions found in article 3-7k(2) exist and guidance from Table 3-2 should be followed. Work/rest criteria do not apply to ships, submarines, and small craft where PHEL curves are to be used. Spot cooling and general ventilation should be used whenever possible. Good airflow increases evaporation and cooling of the skin.

Table 3-8. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV)® and Work/Rest Criteria

	WBGT Values (°C/ °F)							
	Acclimated				Unacclimated			
Chapter B2 Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5/85	27.5/82	26/79	N/A	27.5/82	25/77	22.5/73	N/A
75% Work, 25% rest, each hour	30.5/87	28.5/83	27.5/82	N/A	29/84	26.5/80	24.5/76	N/A
50% Work, 50% rest, each hour	31.5/89	29.5/85	28.5/83	27.5/82	30/86	28/82	26.5/80	25/77
25% Work, 75% rest, each hour	32.5/91	31/88	30/86	29.5/86	31/88	29/84	28/82	26.5/80
Source: ACGIH 2006. Used by Permission.								

(2) These WBGT values are based on the assumption that nearly all acclimated, fully clothed workers with adequate water and salt intake should be able to function effectively under the given working conditions without exceeding a deep body temperature of 38°C (100.4°F). They are also based on the assumption that the WBGT of the resting place is the same or very close to that of the workplace. Where the WBGT of the work area is different from that of the rest area, a time-weighted average should be used (consult the electronic version of the *ACGIH 2008 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* or most current edition) available at: http://www.acgih.org/store/ProductDetail.cfm?id=2014. These WBGT values apply to physically fit and acclimated individuals wearing light summer clothing. If heavier clothing that impedes sweat or has a higher insulation value is required, the measured WBGT value must be adjusted accordingly. If

wearing coveralls or field uniform, add 6 to the measured WBGT value. If wearing body armor or NBC protective clothing, add 10 to the measured WBGT value. Exposure limits should be adjusted accordingly.

Table 3-9. Examples of Work Levels for Navy and Marine Corps Activities

WORK LEVEL	ACTIVITY
Light Work	Sitting - office activities.
	Driving car.
	Standing light work mostly arm movement.
	Standing watch duties.
Moderate Work	Laboratory work.
	Using a table saw or similar equipment.
	Meal preparation and serving.
	Driving a truck, forklift, etc.
	Laundry/dry cleaning work.
Heavy Work	Maintenance/repair work such as replacing tires, engine work, etc.
	Hand sawing wood.
	Pick, shovel, and axe work.
	Setting up tents.
Very Heavy Work	Shoveling wet sand, filling and stacking sand bags.

b. **Ground Forces Guidance**

(1) Guidance for ground forces focus mostly on field training exercises and work schedules.

(2) Field training exercises requiring sustained or severe physical effort should be scheduled, when possible, in early morning or at night. Outdoor classes should be conducted in the shade with adequate exposure to cooling wind. Even when training exercises are performed in early morning or at night, high metabolic heat production by those performing physical activity can induce heat exhaustion or heat stroke. Therefore, it is important to be aware of all factors that may precipitate systemic heat injuries. Careful monitoring of the WGBT index is essential to the prevention of heat injury in the field. Heat casualties can be expected at WBGT readings of 75° F and above, unless preventive measures are instituted. Heavy work can cause heat injury at lower temperatures, especially if body armor or protective clothing is worn.

(3) Work schedules must be tailored to the situation. When temperatures are high, work must be curtailed or even suspended under severe conditions. The temperature at which work schedules modification will take place depends on humidity, radiant heat, wind velocity, character of the work, degree of acclimatization, and other factors. Work can be scheduled during the cooler hours of the day, such as morning and evening, and still meet the workload requirement. In garrison areas it is important that WBGT readings be conducted for the area. While deployed to areas of operation in the field, medical personnel are relied upon to have, operate, and maintain WBGT equipment and follow the work/rest guidance in article 3-9a.

(4) The effects of thermal stress can be lessened within an area while in garrison by employing a few shading techniques to provide protection from the radiant suns rays.

Camouflaged netting can reduce temperatures inside tents and other facilities exposed to the direct rays of the sun. This is especially important in common use areas such as dining tents, recreation areas, and berthing. Hydration of troops should be promoted by providing protected sources of cool drinking water in numerous locations throughout the camp.

(5) The Urine Chart in Figure 3-6 can be used as a guide to determine if personnel are drinking enough water to stay hydrated. Large volumes of relatively clear urine indicate proper hydration. Small volumes and/or dark urine indicate dehydration and the need to drink more fluids. A yellow color associated with a number 4 in the Urine Chart indicates that a service member should be drinking more water and if the color persists should see a medical department representative. Some foods, vitamins, prescriptions, and over-the-counter drugs may alter urine color or have a diuretic effect.

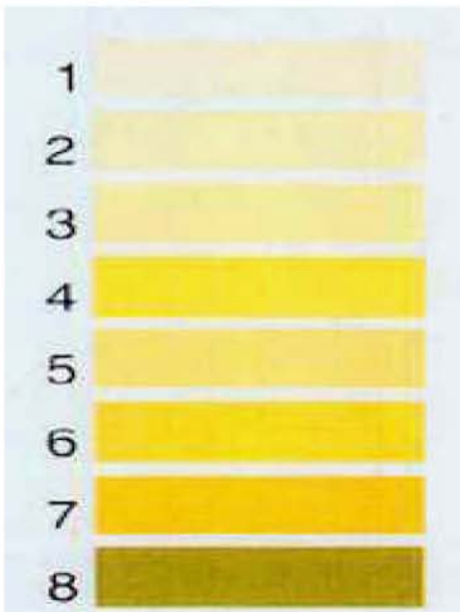

Figure 3-6. Urine Chart

Validated in: Urinary Indices of Hydration Status, INT. J. Sport Nutrition 4:265-279, 1994 and Urinary Indices of Dehydration, Exercise and Rehydration, Int. J. Sport Nutrition, 8:345-355,1988 and Drinking behavior and perception of thirst in untrained women during heat acclimation and outdoor training, Int. J. Sport Nutr. & Exerc. Metab, 13:15-28, 2003.

3-10. Preventive Measures

a. Preventive Measures

(1) Heat disorders have a worldwide distribution and may even occur in cold climates where metabolic heat production exceeds an individual's adaptive abilities. Heat stress is commonly encountered in military operations, and may cause injury or death, resulting in decreased readiness.

(2) Most heat stress injuries are preventable. The body constantly generates heat; activity (work or exercise) generates more heat. The body cools itself in heat stress conditions primarily by sweating. Risk factors and conditions that predispose to heat stress injuries are listed in Table 3-10 below:

Table 3-10. Risk Factors and Conditions that Predispose to Heat Stress Injuries

1. High humidity
2. Lack of air movement (wind)
3. Overhead sun
4. Elevation below sea level
5. Sunburn or other skin condition
6. Clothing or gear that hinders skin “breathing”
7. Illness
8. Recent immunizations
9. Prior heat injury
10. Recent heat stress exposure
11. Age (very young or very old)
12. Lack of acclimation (a new exposure to a hot, humid environment)
13. Dehydration
14. Medications
15. Substance abuse
16. Fatigue
17. High activity level
18. Being around very hot objects (e.g., hot steel)

(3) Preventive measures against heat stress injury are focused on maintaining adequate hydration and limiting strenuous activity. Activity is controlled by observing work-rest cycles, which are established based on the WBGT.

b. **Warning Signs of Heat Strain**

(1) Symptoms (feelings of being overheated or of chills) and signs (confusion, incoordination, decreased sweating, and “gooseflesh”) of impending heat stroke should be closely followed. Checking body temperature can be done using oral (mouth) thermometers (provided the person has not had hot food or water for 5 minutes and cold food or water for 30 minutes) or ear probes (provided no water has splashed in the ear); core temperature may be determined with a rectal or an esophageal thermometer.

(2) Supervisory personnel should be able to recognize the signs and symptoms of excessive heat strain and impending heat stroke and heat exhaustion.

c. **Engineering Methods.** Engineering methods are not always effective and often must be supplemented or preceded by medical measures. In physiologically compensable environments, performance in the heat can be improved greatly by proper selection and acclimation of workers. In all hot environments, improved performance can be achieved by controlling fatigue, nutrition and alcohol, and by periodic examination for underlying illness and the early symptoms

of heat strain. Heat stress and heat strain may cause significant loss of performance, efficiency and duty time due to systemic heat injury. Long-term effects of heat stress and strain include the progressive loss of performance capability, increased susceptibility to other forms of stress, reduced heat tolerance, and the potential for permanent disability.

d. **Sweating.** Evaporation of perspiration from the skin (sweating) is the primary way the body loses heat when the air temperature exceeds 95° F. Evaporative heat loss from the respiratory mucosal surfaces is minimal, representing perhaps only 2 percent of the metabolic heat. Thermoregulation is mediated by circulatory (e.g., central and capillary blood flow), neural (e.g., hypothalamic, autonomic pathways), and biochemical (e.g., ionic and endocrine) functions involving central or peripheral levels of response. When temperature balance mechanisms for the body fail, the body's core temperature will continue to increase. As heat storage increases; skin and deep-tissue temperature rise; cardiovascular, respiratory and metabolic functions accelerate; and, renal function is depressed. Increased metabolic heat pushes the cycle faster to the point of cardiovascular and renal failure and irreversible damage to the nervous system and muscles. The cycle can be broken only by timely and definitive therapy. Therefore, every effort should be made to relieve excessive stress on each individual's heat regulating mechanism. The following measures will assist in reducing systemic heat injuries:

(1) **Acclimation**

(a) Acclimation is important to prevent heat stress injuries. Acclimation can best be accomplished by exposing individuals to a gradual increase in physical training and work in a hot, humid environment over a period of days or weeks. Various body systems adapt at different rates, but two thirds or more of the adaptation may be obtained within 5 days. Advantages of acclimation include the following:

- Tolerance of and performance in heat stress conditions is improved.
- Sweat rate increases and begins at a lower core temperature.
- Sweat sodium concentration decreases.
- Plasma volume increases.
- During exercise in the heat there is lowered heart rate and lowered core temperature at each level of sub-maximal workload.
- A decrease in perceived exertion.
- The level of hyperkalemia is attenuated after acclimation (mild exercise in severe heat conditions induces significant hyperkalemia).
- Men exercising in the heat have an increased ability to conserve sodium.

(b) Heat acclimation occurs more rapidly in persons who are physically fit. Physical conditioning is also advantageous in the body's response to dehydration, a heat stress-related condition. However, inactivity results in decreased acclimation after only a few days or weeks, and exposing heat-acclimation individuals regularly to cold temperatures (e.g., 4 hours daily for 21 days) can cause a significant loss in heat acclimation. To achieve maximum benefits from acclimation, it is extremely important that moderate (more than sedentary) work be performed during the adaptation process.

(c) Stable acclimation at any one level of heat stress does not guarantee full acclimation to a higher level of heat stress. Various body systems adapt at different rates.

(d) Table 3-11 illustrates the percent achievement of optimum heat acclimation for 13 physiological parameters after consecutive days of exposure while performing moderate physical work. Overall optimum heat acclimation to hot-humid conditions of 95ºF DB, 88ºF WB and air movement of 100 fpm was achieved in 22 consecutive days of heat-work exposures. As can be seen in Table 3-11, there are three distinct stages of acclimatization, of which the third stage begins after the 7th consecutive day of inducing heat acclimation.

Table 3-11. Percent Optimum Heat Acclimation

Physiologic Parameters	Percent Achievement On:			
	Day 1	**Day 7**	**Day 14**	**Day 21**
Rectal Temperature	6	38	72	100
Tympanic Membrane Temperature	6	37	71	100
Deep Esophageal Temperature	51	82	93	100
Mean Skin Temperature	80	93	98	100
Heart Rate	8	37	67	100
Systolic Blood Pressure	11	38	56	100
Diastolic Blood Pressure	7	36	70	100
Pulse Pressure	9	36	63	100
Mean Arterial Blood Pressure	4	35	79	100
Est. Total Vascular Resistance	8	37	70	100
Est. Cardiovascular Reserve	7	36	69	100
Sweat Rate	3	37	76	100
Urine Osmolarity	3	39	82	98
Overall Percent Achievement	**13**	**45**	**78**	**99.6**

(2) **Fluids (Drinks).** Water, electrolyte solutions (sports drinks), or even carbonated beverages may be used to replace fluids lost through sweating. Water is generally adequate, readily available, and should be encouraged as the main means to stay hydrated. The extra electrolytes in sports drinks are not necessary, and soft drinks contain high amounts of sugar, carbonation and acidity. However, if water is not readily available, sport drinks or soft drinks (preferably caffeine free) are acceptable alternatives. Supervisory personnel must know that personnel cannot be trained to resist dehydration. "Water discipline" (i.e., learning to go without water in the heat) must be replaced with "Water freedom" where drinking moderate amounts of cooled water at frequent intervals is encouraged. "Forced drinking" (i.e., drinking even though not thirsty) during activity in hot environments should be used, as thirst lags behind actual need for water. An individual may lose up to 2 percent of body weight before feeling the sensation of thirst.

(3) **Salt.** Salt intake is especially important in the early stages of heat acclimation. The current estimated "normal" dietary intake of sodium chloride in the general United States population is approximately 15 grams daily, generally adequate even in the early stages of heat acclimation (when salt concentration in sweat, and thus salt loss, is highest). This estimate

includes the common practice of saltshaker supplementation prior to tasting of served food. Salt tablets should never be used except under medical supervision. Use of salt tablets during exercise in the early stages of acclimation, if required, must be closely monitored by medical personnel. Proper sodium chloride level can be achieved by providing adequate water, a normal diet, and a saltshaker on the table for conservative use, with no more than the equivalent of 2.0 grams of supplementary salt per day. Deviations from these recommendations must be governed by the past and present medical histories of individual workers and adjusted according to individual need by the Medical Department Representative (MDR). Field rations contain a variable amount of sodium chloride, dependent upon the Federal Stock Number and the manufacture dates. Standard Military Rations, including A Ration, B Ration, T Ration, Meal, Ready-to-Eat (MRE), and the Go to War Ration (GTW), contain 5-7 grams of sodium (about 12.5-17.5 grams of salt) per meal. Restricted Rations, including Ration, Lightweight (RLW-30), Food Packet, Long Range Patrol (LRP), and Food Packet, Survival, General Purpose Improved (GP-I), contain 2.5-3.5 grams of sodium (about 6.5-9 grams of salt) per meal. Field grade salt tablets are 10 grain (0.648 grams; 0.255 grams of sodium and 0.393 grams of chloride) each.

(4) **Scheduling Activity**

(a) Training exercises requiring sustained or severe physical effort, and those conducted in the prone position should be scheduled, when possible, in early morning or at night. Outdoor classes should be conducted in the shade with adequate exposure to cooling wind.

(b) When environmental heat stress is excessive, heat illness can be prevented by curtailing or suspending non-essential physical training and undue heat stress exposure. If operational mission requirements, excluding training programs, may preclude application of pertinent heat stress guides, the Medical Department should be forewarned in order to adequately prepare facilities and staff for the anticipated increased number of heat illnesses. Mental and physical dysfunction under thermal stress may be expected to amplify the frequency of accidental injury and mishaps.

(5) **Recovery.** Adequate recovery from acute or cumulative fatigue (at least 6 hours of uninterrupted sleep in a thermally comfortable thermal environment per 24 hours), optimal physical fitness for the work to be done, and absence of illnesses or of febrile reactions (e.g., elevated body temperature due to immunizations) will increase resistance to heat stress injury.

(6) **Clothing.** Clothing should be worn loosely at the neck, at the cuffs of sleeves, and at the bottom of trousers to facilitate convective cooling (cool air carrying heat away from the body). PHEL values do not need to be adjusted provided engineering, fire-retardant; Nomex® coveralls are worn only over underwear. Wearing Navy coveralls over any other clothing imposes a major heat load upon the body due to added insulation and weight, and is not recommended in hot, humid environments. Starch must not be utilized where evaporative cooling from clothing is a major factor. Outdoors, helmet liners or headgear of similar design provide more cooling and protection of the head than caps.

(7) **Cooling Systems.** Some microclimate cooling systems have been shown to be a safe and effective means of reducing or preventing the ill effects of heat stress. There may be highly specialized applications of such units, but each remains to be carefully examined with sufficient supporting data. Where possible, the key issue is to perform the necessary corrective engineering actions to eliminate impedances of the workers and permit the workers to perform their normal duties in an effective manner without physical encumbrances. However, there are environments, work locations, or work activities where engineering actions are not feasible and a cooling system may be appropriate. Cooling systems should be evaluated before Fleet implementation as vendors have become very aggressive in marketing their product directly to the Fleet without the appropriate medical and scientific evaluation. Each cooling system should be evaluated with regard to the effectiveness to provide adequate cooling with little impact on ergonomics, unrestricted body movement, and optimum safety of personnel. As such, all cooling garment products should be evaluated by BUMED prior to use in the Fleet and some microclimate cooling systems may require a more comprehensive physiological and environmental evaluation.

3-11. Medical Treatment

a. The treatment of heat stress injuries is beyond the scope of this document. The technical manual, Prevention and Treatment of Heat and Cold Stress Injuries at: http://www-nehc.med.navy.mil/Downloads/Occmed/heat_cold_stress_manual/Heat_and_Cold_final_June07.pdf contains detailed guidance for treating heat stress injuries.

b. Medical texts, established military treatment facility procedures, the above technical manual, and experienced medical providers should be consulted as necessary.

Section III. Cold Stress

3-12. Cold Stress Effects

a. The adverse effects of low environmental temperatures on the human body may be localized or generalized, or both. They may occur at temperatures above or below freezing and under wet or dry conditions. The features of cold injury are dependent on the environmental temperature (ambient and wind chill temperature), exposure time and individual susceptibility or resistance. The body's response to total cooling is to try and maintain thermal energy and increase heat production. Shivering is the body's attempt to increase heat production. With prolonged or severe exposure, the defense mechanisms fail, heat loss exceeds heat production, and the body temperature falls.

b. Cold-related injuries are usually preventable. Preventive measures include providing adequate clothing, nutrition, hydration, and dry shelter, limiting or avoiding alcohol, and allowing gradual acclimatization. Proper clothing is especially important, such as dry suits for diving, anti-exposure suits on deck (also gear for the face, hands, feet and head), as well as changing socks at least daily. Using proper equipment, such as plastic-coated tools and equipment (instead of handling bare metal), will also help in reducing cold-related injuries. Wind speed (wind chill) must always be taken into account when considering the severity of cold stress.

c. Each individual should know how to minimize cold stress, recognize the symptoms of cold injuries, and provide basic first aid. Common cold stress conditions are listed in article 3-16.

3-13. Environmental Measurements - Wind Chill

a. The wind chill temperature is how cold the human body will feel due to a combination of cold temperature and air movement (wind). As the air speed increases in cold temperatures, heat is drawn from the body, driving down skin temperature and eventually the internal body temperature. Therefore, the combination of wind and temperature creates the effect of wind chill, which makes it feel much colder. The Wind Chill Temperature Index is displayed in Figure 3-7.

b. Check the operating range of the meter being used to measure temperature in cold environments, as most meters used to measure heat stress may not be designed for use in cold environments. An anemometer or wind gauge will be required to measure wind speed.

Wind (mph)	Temperature (°F)																	
Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5	36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10	34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15	32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20	30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25	29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30	28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35	28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40	27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45	26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50	26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55	25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60	25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times: 30 minutes; 10 minutes; 5 minutes

$$\text{Wind Chill (°F)} = 35.74 + 0.6215T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$$

Where, T= Air Temperature (°F) V= Wind Speed (mph)

Effective 11/01/01

Figure 3-7. National Weather Service Wind Chill Temperature Index

3-14. Preventive Measures

a. **General Prevention.** Cold stress presents challenges to the body in retaining heat produced by metabolism. Most cold-related health consequences are preventable. Preventive measures include ensuring adequate shelter and clothing (especially gear for the face, hands, feet, and head), adequate nutrition and hydration, limiting or avoiding alcohol, gradual acclimation (taking a few weeks “to get used to the cold”), changing socks at least daily (or more often if wet), using proper equipment (such as dry suits for diving, anti-exposure suits on deck, and plastic-coated tools and equipment), taking wind speed and precipitation into account, and exercising sound judgment. Predisposing factors to cold injuries include both physiological and psychological as discussed in article 3-14b:

b. **Risk Factors**

(1) Within the usual age range of sailors and Marines, age is not significant as a factor of susceptibility to cold injury.

(2) A previous episode of cold injury increases an individual’s susceptibility to subsequent cold injury.

(3) Mental weariness or fatigue may cause apathy, leading to neglect of acts vital to survival.

(4) Too much or too little activity will contribute to cold injury. Over activity, with deep, heavy breathing generates a large amount of body heat loss. The resulting perspiration, which becomes trapped in the clothing, markedly reduces the insulating quality of the clothing. Conversely, immobility causes decreased body heat production that results in cooling, especially of the extremities. Too much or too little activity will contribute to cold injury. Wiggling the fingers and toes and massaging the ears and nose periodically will increase circulation and keep them warm. When exercise is not possible, frequent changes of position will encourage circulation.

(5) Humidity affects environmental cold stress by affecting how quickly evaporation (for example, of sweat) from the skin takes place. Under dry conditions, a person with moist or wet skin who finishes exercising will lose heat rapidly. Soaked skin or clothing may increase conductive and convective heat loss in a cold environment, especially if there is contact with cold surfaces or cold moving air.

(6) Personnel from warmer climates appear to be predisposed to cold injury. However, proper acclimatization will help compensate for this predisposition.

(7) Proper personal hygiene must be maintained in cold weather operations. Personnel involved in field operations may neglect basic hygiene and become susceptible to skin disease because of the lack of hot water and convenient washing facilities.

(8) Poor nutrition predisposes a person to cold injury. The standard military ration will provide adequate nutrition for appropriately clothed and protected personnel during most cold weather operations. Increased caloric intake, especially in the form of carbohydrates, is important for the production of internal body heat in very cold operations. Proper nutrition includes hydration. Adequate water intake is as important in cold environments as in hot since personnel may not be aware of sweat they are losing. Adequate water drinking must be maintained in cold environments.

(9) Medical personnel will find detailed information on salt and water requirements in article 3-10d(2) and 3-10d(3). However, it is important to note that caution must be taken to prevent dehydration from occurring in the cold and at altitude even though this is far different from a heat stress environment typically associated with dehydration.

(10) Personnel taking prescription medication must be aware that some drugs have an adverse effect on blood circulation or sweating.

(11) Alcohol can impair judgment and will cause dilation of peripheral blood vessels, which results in increased heat loss to the environment. Alcohol (ethanol) can cause cutaneous capillary dilation, which in turn may inappropriately increase cutaneous blood flow during cold exposure. Skin temperature fall will be blunted, while core temperature will fall more quickly. More importantly, alcohol may diminish appropriate behavior (such as seeking shelter from cold, changing into dry clothing, etc.).

(12) Nicotine causes the peripheral blood vessels to constrict thereby decreasing blood flow to the extremities, possibly predisposing to local cold injury (such as frost bite).

c. **Acclimation (Acclimatization).** Acclimation refers to the adaptation to cold stress that occurs after repeated exposure to cold stress conditions. Acclimation refers to adaptation that occurs after laboratory-controlled exposure to cold. Proper acclimation will result in a delayed onset of shivering and a lower core body temperature. Benefits of acclimation to cold are very limited compared to benefits of acclimation to heat.

d. **Clothing**

(1) **Wear or carry adequate amounts of the proper types of clothing** for the weather to be encountered. Clothing must be worn in layers so excess layers can be removed before sweating causes the material to lose its insulating properties. Outer layers should be wind resistant. Loose clothing allows for efficient blood circulation and creates air pockets that provide insulation. The clothing must be clean and dry. The rain suit must be large enough to fit over the cold weather clothing. Wearing NBC protective clothing during strenuous activity in cold weather may increase the risk of hyperthermia (and even heat injury) and cause sweat accumulation in clothing; this compromises insulation and increase the risk of hypothermia during subsequent periods of inactivity. All exposed skin areas need protection from the cold and wind. The face is especially vulnerable to cold injury; as much as 75 percent of body heat loss is through the head. Heat injuries may occur in cold weather operations, so wearing the clothing as stated above can help prevent such an occurrence.

(2) **The feet must be given special attention.** Cold weather, insulated, rubber boots (black or white) will be issued to troops during cold weather operations. Frequently changing socks is important with these boots because of increased foot sweating (retention of sweat may lead to fungal infections). Sweat in these boots can lead to softening of the soles of the feet, skin loss, infection, and hospitalization. Cold injuries can still occur in these boots if the feet are not exercised. While wearing boots, feet are more prone to sweating. Moisture in the socks will reduce their insulating quality, so frequent sock changes are essential. Extra socks must be carried at all times and dirty socks washed whenever possible. Sweating of the feet may be controlled by the use of antiperspirants containing aluminum chlorhydrate. Feet should be massaged daily, toenails trimmed (not too short), and blisters cleaned and protected.

(3) **Mittens are more protective than gloves.** Gloves present more surface area for heat loss and are therefore less efficient than mittens in keeping hands and fingers warm. When wet, leather gloves must be dried slowly to prevent shrinking and hardening of the leather. The wool liners must be dried slowly to prevent shrinking.

e. **Carbon Monoxide.** There is increased risk of carbon monoxide poisoning in cold weather. As fuels are burned to provide warmth, carbon monoxide is given off. The colorless, odorless gas can cause asphyxiation in poorly ventilated spaces. Personnel must be aware of and constantly reminded of the need for adequate ventilation of enclosed spaces where fuel heaters are being used.

f. **Eye Protection.** Normally, much of the solar radiation which reaches the earth is absorbed into the ground and the surrounding environment. In the snow, however, the majority of the sun's rays are reflected off the facets of ice crystals; reflected rays may be absorbed by the skin or pass into the eye. When working in snow conditions, use of sunscreen and sunglasses is strongly recommended. Sunglasses must be worn during daylight hours regardless of whether the sun is shining brightly or not. A bright, cloudy day is deceptive and can be dangerous to the eyes and skin as can a day of brilliant sunshine. Glasses will also protect against blowing snow. The risk of snow blindness and sunburn is increased at high altitudes; thin, clear air allows more of the burning rays of sunlight to penetrate.

g. **Signs of Cold Injuries.** Personnel must be trained to recognize signs of cold injuries on other individuals. When blanching of the skin is noted, immediate action will usually prevent the development of cold injury. Holding (not rubbing) a warm hand on the blanched area until it returns to a normal color is an effective treatment for a cold ear, nose, or cheek. Fingers can be warmed against the bare abdomen, chest, or armpit. If the casualty complains of an abrupt loss of cold sensation or extreme discomfort in the affected body part, immediate action must be taken, as these are classic early signs of a cold injury.

h. **Manual Dexterity.** Exposure to the cold may negatively influence manual dexterity. Hand skin temperature, rather than body surface temperature, is the critical factor; when hand skin temperature is 55°F (12.8°C) or lower, manual performance is impaired. Touching very cold objects (such as touching cold metal with the tongue or fingers) may freeze the body part to the object; the frozen part and object should be warmed until they can be easily separated, as pulling away will damage the skin.

3-15. Cold Water Immersion

a. **Effects of Cold Water Immersion.** Immersion in cold water impairs swimming performance (at 64°F or 18°C). Personnel immersed in cold water cannot reliably assess how cold they are. With immersion in mildly cool water, stability of the temperature of cutaneous receptors may lead to hypothermia without personnel being aware of their condition. In frigid water complex physiological responses are triggered that shut down the blood circulation to most parts of the body except heart, lungs, and brain. Though blood, in such situations, contains only a limited amount of oxygen, it can be enough to sustain life and prevent damage to brain tissue for considerable periods of time, if body core temperature has dropped (a cooled down brain needs less oxygen than one at normal temperature). It takes 10-15 minutes before the deep body temperatures start to drop; surface tissues cool quickly. A victim may experience labored breathing and stiffness of limbs. As core temperature drops to 95ºF there will be violent shivering; at 90-95ºF mental facilities cloud; at 86-90ºF there is muscular rigidity and loss of consciousness. Below 86ºF there is diminished respiration and possible heart failure, below 80ºF respiration becomes almost undetectable and death is imminent.

b. **Cold Water Survival**

(1) Survival time in cold water will depend on several factors, such as water temperature, sea state, and having a floatation device. In cold water at 32°F (0°C) the ventilation rate initially increases (more than 4 times baseline for the first 2 minutes of immersion). After 10 minutes of immersion, mean skin temperature falls to 41°F (5°C). After 20 minutes of immersion, maximum shivering metabolism peaks. Swimming increases heat production to 2.5 times that of holding still in cold water but also increases the cooling rate 35 percent. The colder the water the shorter the survival time (e.g., 1 hour at 32°F or 0°C). Figure 3-8 shows the survival time in cold water as a function of water temperature. Actual survival without flotation devices may be much less.

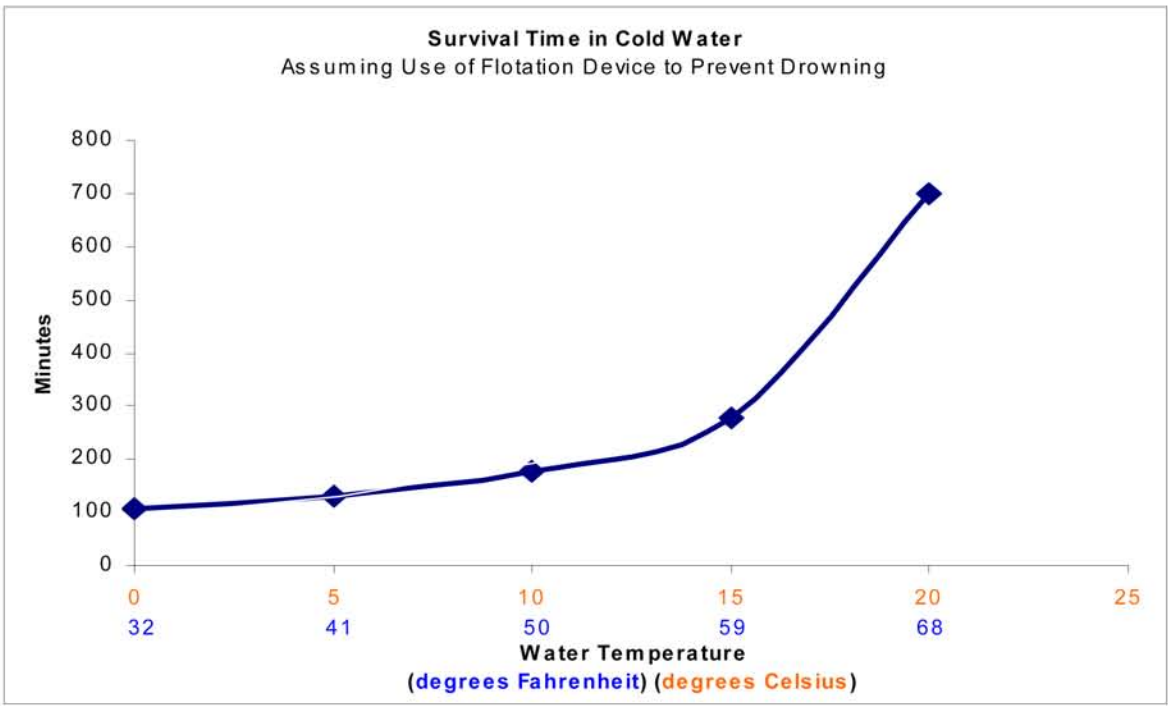

Figure 3-8. Survival Time in Cold Water (Estimated)

(2) ***<u>Do's</u>*** **of cold water immersion:**

- Wear a personal flotation device and several layers of clothing.
- Try to keep lungs inflated with air to maintain buoyancy.
- Use minimum movement to prevent the escape of trapped air in clothing, which acts as an insulator.
- Maintain Heat Escape Lessening Posture (HELP) until help arrives. The HELP position is basically fetal position with arms and legs withdrawn close to the body. An alternative is to huddle with two or more persons in the water.
- Take advantage of floating objects.

(3) ***Don'ts*** **of cold water immersion:**

- Do not panic. Actions within the first 10 seconds can mean survival or death.
- Do not struggle. Struggling will squeeze insulation air out of clothing and ingesting cold water may constrict breathing passages.
- Do not swim for land that is over a mile away.
- Do not remove clothing.
- Do not float on your back. Instead rely on the natural buoyancy of the body and use the hands in a semi-vertical position in the water, with the head just above the water surface. The greatest heat loss is from the head and neck so immersion of those areas by floating on the back, can swiftly begin the onset of hypothermia and death.

3-16. Cold Stress Exposure Injuries, Treatment, and Reporting. There are four common types of cold stress injuries: cold shock, nonfreezing injuries, freezing injuries, and hypothermia. The terms "nonfreezing" and "freezing" injuries refer to localized areas of the body exposed to cold stress, which may result in temporary impairment or permanent scarring or loss of the affected body part. Whole-body cold stress can result in hypothermia, which, if severe or if not treated in time, can result in organ damage or death.

a. **Cold Shock.** "Cold shock" (not true "shock" in the medical sense) may be produced when personnel pass from heated areas into air-conditioned spaces. Individuals experience a rapid loss of body heat due to an increased evaporation of sweat from wet skin and damp clothing. Persons entering cold rooms (e.g., walk-in freezers, cold storage boxes, etc.) should be protected by the temporary use of suitable clothing or limiting the frequency and duration of exposures.

b. **Non-freezing Cold Injury.** Non-freezing local (i.e., limited to one part of the body, such as hands or feet) injuries occur at ambient temperatures above 32° F, and are associated with prolonged exposure to cold water or dampness.

(1) **Trench foot** is a non-freezing cold injury of the feet. Symptoms of trench foot are cold, numbness, paresthesias, itching, and painful weight bearing, progressing to anesthesia ("walking on blocks of wood"), painful blisters, and local hemorrhage. Signs include pallor, mottled purple coloration, swelling, and edema. After rewarming, sensation returns with paresthesias, pain, and increased heat sensitivity. Blisters, circulatory compromise, local hemorrhage, and ecchymosis may characterize severe cases, which may have a prolonged post-inflammatory phase involving compromised blood supply. Trench foot may result in a peripheral neuropathy.

(2) **Chilblain (chilblains)** is a red or purple discoloration of the distal extremity skin (including ears and nose) occurring after exposure to the cold (generally moist cold). It is most common in young women although it can happen at every age, and relapses characteristically in autumn and winter. It also may be associated with underlying connective tissue disorders (specifically lupus erythematosus). Symptoms include pruritic, painful (especially burning) red patches on the fingers and/or toes, generally bilaterally. Sunlight may aggravate the lesions. Significant scarring may result.

(3) Keeping clothing and exposed extremities dry is the primary preventive measure against non-freezing cold injury.

c. **Freezing Injury.** Freezing injury, commonly referred to as frostbite, only occurs at environmental temperatures below freezing.

(1) The extent of tissue destruction depends primarily on the environmental temperature and length of exposure.

(2) Frostbite symptoms include a cold or burning sensation, progressing to numbness. Frostbite is classified as first (superficial), second (full-thickness, usually with clear blisters), third (skin and subcutaneous tissue, sometimes with hemorrhagic blisters), and fourth degree (deeper structures, including tendons, muscles, and bone).

(3) Signs of frostbite vary and include white patches, diffuse redness, hardening or waxy appearance of the skin, mottled gray coloration, tenderness, diminished light touch, and anesthesia (no sensation).

d. **Hypothermia.** Hypothermia is a general cooling of the body's core temperature. Whole body exposure to cold temperatures, wind, wet clothing, or cold water immersion are the primary contributing factors. Treatment is immediate removal from cold exposure, changing to dry clothes, and rapid rewarming. Victims of severe hypothermia should be immediately evacuated to a medical treatment facility.

e. **Cold stress** may also exacerbate or unmask underlying conditions, such as acrocyanosis, rosacea, cold agglutinin disease, cold panniculitis, xerosis, cold-induced urticaria, vibration white finger, Raynaud's phenomenon, and paroxysmal cold hemoglobinuria. Persons with those conditions should take extra precautions to wear adequate clothing and equipment, or avoid cold stress exposure entirely.

f. **Treatment of Cold Stress Injuries**

(1) The treatment of cold injuries is rewarming.

(2) Affected parts should be elevated and kept stationary.

(3) Avoid weight-bearing positions.

(4) Do not rub the affected area.

(5) Smoking should be prohibited until recovery is complete.

(6) Chilblain and trench foot injuries are best rewarmed using air at room temperature. Rewarming may be done even though re-exposure to cold is anticipated.

(7) Rewarming of frostbite should be delayed until the victim has been removed from risk of re-exposure to the cold and can be kept at bed rest. Treatment of frostbite is rapid rewarming, using immersion in water at or just above body temperature (no more than 108°F or 42.2°C). Additional measures include intravenous fluids, medication, and hyperbaric oxygen. Frostbite victims should receive prompt and ongoing medical care.

(8) Cold injury victims may show signs of cardiovascular arrest that reverse after rewarming, and should be aggressively treated. The Emergency Medicine Manual (available for purchase only) states that "no one is dead until they are warm and dead."

g. **Reporting Requirements**

(1) All Navy cold stress-related injuries shall be reported through the Naval Disease Reporting System per BUMEDINST 6220.12 series. A simultaneous report to the Naval Safety Center should be made using the Web Enabled Safety System (WESS) per OPNAVINST 5102.1 series.

(2) Marine Corps cold injuries shall be reported per MCO P5102.1 series (which prescribes the mandatory use of electronic mishap reporting of all Marine Corps ground mishaps to the Marine Corps database maintained at the Naval Safety Center) and BUMEDINST 6220.12 series (which stipulates Naval Disease Reporting System electronic report, or written, fax, e-mail, or telephone report to the cognizant NAVENPVNTMEDU.

(3) Reporting requirements contained in the publication are covered under the report control symbols established in OPNAVINST 5102.1 series and BUMEDINST 6220.12 series and are good for 3 years from the date of these instructions.

h. **Form.** NAVMED 6500/1, Report of Heat/Cold Injury, S/N 0105-LF-015-0800 is hereby canceled.

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Section IV. Abbreviations

ACGIH	American Conference of Governmental Industrial Hygienists
AHSS	Automated Heat Stress System
AH	Absolute Humidity
At1	Allowed PHEL Time In First Environment
At2	Allowed PHEL Time in Second Environment
BEI	Biological Exposure Indices
BTOW	Boiler Technician of the Watch
BUMED	Bureau of Medicine and Surgery
CFM	Cubic Feet Per Minute
CNI	Commander, Naval Installations
COTS	Commercial off-the-Shelf
DAVIS/DITIS	Defense Automated Visual Information System/Defense Instructional Technology Information System
DB	Dry-Bulb
EMOW	Electrician Mate of the Watch
EOOW	Engineering Officer of the Watch
ERO	Electronics Readiness Officer
Et	Elapsed Time
FFE	Firefighting Ensemble
FPM	Feet Per Minute
GP-I	General Purpose Improved
GT	Globe Thermometer
GTW	Go to War
HELP	Heat Escape Lessening Posture
LRP	Long Range Patrol
MDR	Medical Department Representative
MMOW	Machinist Mate of the Watch
MOPP	Mission Orientated Protective Posture
MRE	Meal, Ready-to-Eat
NAVENPVNTMEDU	Navy Environmental and Preventive Medicine Unit
NAVSEA	Naval Sea Systems Command
NBC	Nuclear, Biological, or Chemical
NIOSH	National Institute for Occupational Safety and Health
NMCPHC	Navy and Marine Corps Public Health Center (previously NEHC)
NSN	National Stock Number
PELs	Permissible Exposure Limits
PHEL	Physiological Heat Exposure Limits
POOW	Petty Officer of the Watch
PPE	Personal Protective Equipment
PSM/ERM	Platform Support Module/Extended Range Munition
PT	Physical Training
R	Recovery Time

RH	Relative Humidity
RLW	Ration, Lightweight
RSSt	Remaining Safe Stay Time
SSTG	Ship Service Turbine Generator
Td	Dew Point
TLV	Threshold Limit Values
Toor	Gas Pressure
TWM	Time Weighted Mean
V	Velocity
VP	Vapor Pressure
WB	Wet-Bulb
WBGT	Wet-Bulb Globe Temperature
WESS	Web Enabled Safety System
WGT	Wet Globe Temperature